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CLASSIFICATION OF NEURAL NETWORK FOR TECHNICAL CONDITION OF TURBOFAN ENGINES BASED ON HYBRID ALGORITHM

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Abstract

Purpose: *This work presents a method of diagnosing the technical condition of turbofan engines using hybrid neural network algorithm based on software developed for the analysis of data obtained in the aircraft life.* ***Methods:*** *allows the engine diagnostics with deep recognition to the structural assembly in the presence of single structural damage components of the engine running and the multifaceted damage.* ***Results:*** *of the optimization of neural network structure to solve the problems of evaluating technical state of the bypass turbofan engine, when used with genetic algorithms.*

Keywords: artificial intelligence; air-gas channel; bypass turbofan engine; diagnostics; neural network.

1. Introduction

One of the purpose of a high level of safety and efficiency of aircraft is the development and introduction of effective systems for evaluation of technical condition of complex technical objects, such as aircraft jet engines (turbojet), which is of particular relevance to their operating technical condition in business aviation.

Existing methods and means of identifying the vehicle turbofan on functional parameters with subsequent localization of the fault to the structural assembly of the engine are running the probabilistic nature of the diagnosis. The task of increasing the reliability of the technical diagnosis for turbofan remains relevant in relation to the existing space features stochasticity and engine states. Improving the accuracy of determining the vehicle engine is complicated by the need to include in the process of diagnosing a significant number of features that reflect the interaction of various structural components and elements of the flow, which in turn leads to a complication of algorithms, software and hardware support process.

The construction of efficient algorithms for diagnosis is only possible through the use of statistical models that reflect the behavior of the object identification in different states. Simulation of complex objects (systems), such as turbofan, complicated problem of inaccurate or incomplete descriptions of the object being studied [1].

In the method of parametric diagnostic turbofan process is based on a comparison of the mathematical model of the specific engine model with standard (serviceable) model of engine.

Artificial intelligence techniques, including on the genetic algorithm, are becoming more common in various areas of research and are gradually being introduced in the diagnosis of complex technical systems. Thus, there is a need to develop new approaches to the technical condition classification of aircraft.

Currently in addressing a wide range of applications more and more attention is paid to the use of hybrid technology, implementing an integrated use of hybrid algorithms and artificial intelligence techniques developed within the framework of the theory of fuzzy sets theory of genetic algorithms (GA), theory of neural network, theory multisets [2].

The article discusses the possibility of applying the approach for solving diagnostic tasks using

intelligent automated systems using the hybrid algorithm.

2. Research method

The neural network has a set of neurons that are interconnected in such a way that there is an interaction between them. The method determines the connections of neurons neural networks architecture [3].

Genetic algorithms originally applied to solve problems of adaptation of mathematical models of the object under study. In [2] Recombination was introduced in evolutionary strategies. GA Principles are based on the terms borrowed from genetics. The formulation of the problem involving multiple criteria (target functions and performance criteria), which must be optimized simultaneously.

Advantages GA consist primarily in the possibility of sharing with other optimization techniques, developed numerous hybrid GA [3]. The most common approach is to include local optimization along with genetic operators in a classic block diagram of a simple GA. In this case, local optimization is applied to each result obtained algorithm (child) to "move" towards a local optimum before implementing it in a new population (obtaining new values). This GA is used for the global expansion of the search space, while heuristic methods are used to find the closest possible solutions.

The GA could solve applied problems by encoding their solutions in the chromosome. The deviation of the new solution of the classification problem of optimization goals, defined in the length it allows adaptation measures to influence the future course of selection decisions to a new population of the GA. In this interpretation it can be seen that the GA - is a virtual reflection of the real semblance of life processes of a living organism in an effort to preserve its unique character and its identity and thus save themselves from external mutagenic effects. This factor ensures the stability of the classification expert system, built using GA, and the selection of unnecessary information data in association with the input features Sensor detection solution at the outlet.

One promising area of hybrid systems is the sharing of technologies such as artificial neural networks, genetic algorithms, fuzzy systems, various modifications of the optimization algorithms.

Using genetic algorithm to train the neural network has the following advantage - the opportunity to study the search space by a plurality of solutions. This has a significant effect when searching for global minimums adaptive reliefs. Genetic algorithms are insensitive to the growth of the dimension of the optimization of the set. At the same time there is a significant drawback of using genetic algorithms - serious computing, and therefore time-consuming. Also, genetic algorithms contain elements of heuristics method therefore have all the disadvantages of heuristic methods.

3. The method of a hybrid algorithm

The essence of hybrid algorithms is a combination of a genetic algorithm with some other search method for solving the problem. At each stage of the GA each received "descendant" is optimized by this method, and then made the usual genetic algorithm for action. This type of development is called Lamark`s evolution, in which individual (inherent data) can be trained, and then to record their property in their own genotype, to then pass to their descendants. Although this method impairs the ability of the algorithm to seek a solution by selection of hyperplanes, but from a practical point of view, hybrid algorithms are more efficient than traditional ones. The hybrid algorithms, there is a strong likelihood that one of the individuals fall into the area of the global maximum and after optimization will be the task.

It has great potential use of hybrid schemes using GA and neural networks (NN). This issue has recently dedicated many works of such scholars as: J.-T. Kuo (4), Saemi M.[5] and others. These algorithms are based on hybrid technology or surrogate modeling metamodeling, involving the replacement of full-scale model of the research object at a much less resource-intensive model, approximately reproducing the response of the original model. Theory metamodeling developing, in particular, scholars such as E. Lotfi [6], D. Goldberg [7], G. G. Wang (8), etc.

To use hybrid algorithm it is necessary to train the neural work. It uses 3 sets (data), describing the

considered: training, control and test. In this study and control the initial data are obtained, as a rule, the methods of numerical experiment using a mathematical model turbofan engines [9].

Mathematical model of engine must have a system of nonlinear equations to describe:

- structural characteristics of the elements and nodes;
- conditions of teamwork structural engine components;
- Engine control laws at steady state operation.

Mathematical model of turbofan engines made in a modular fashion, presented in the form of software modules. Fig. 1 shows an example of an effective hierarchy of hybrid GA [10].

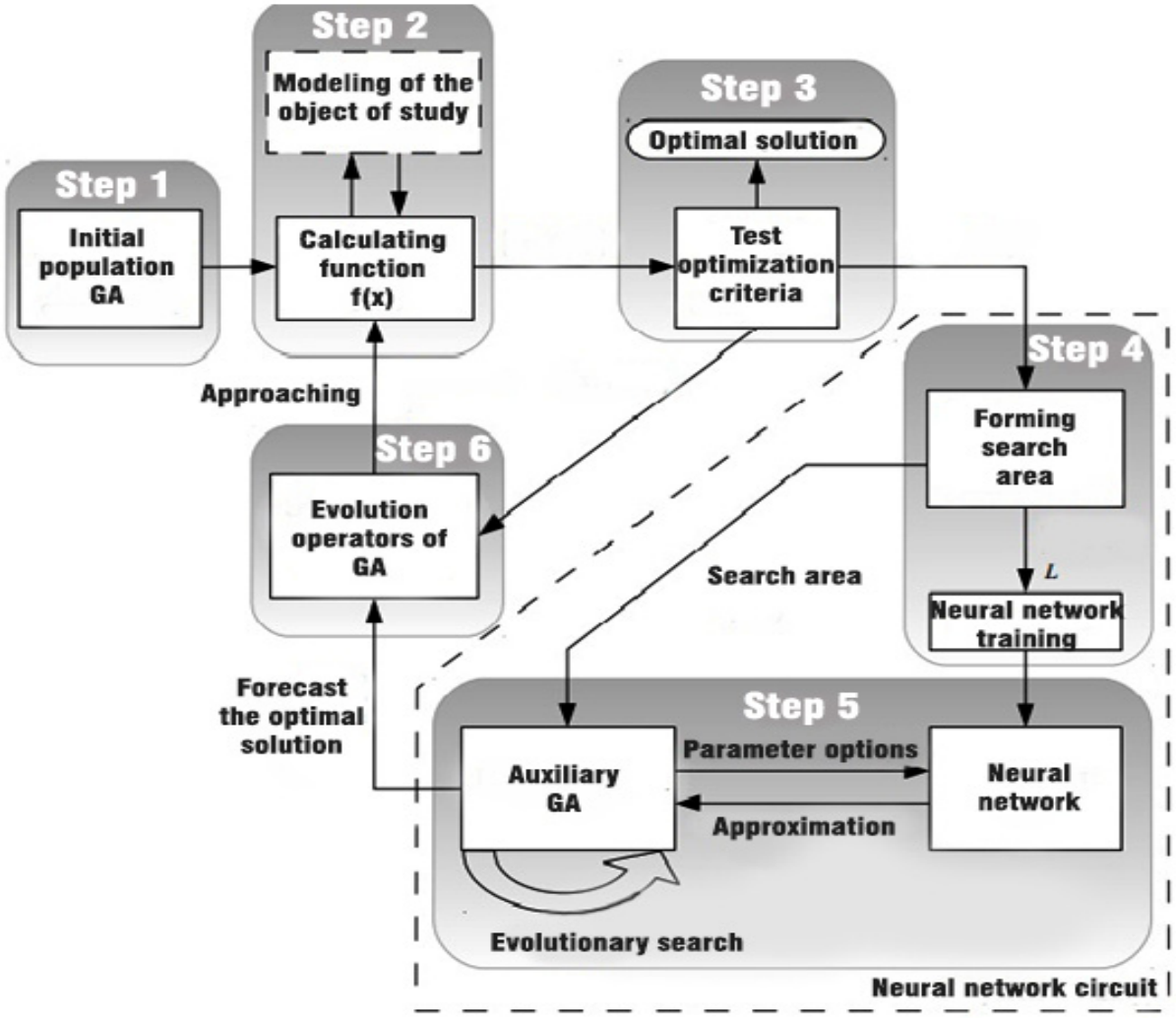

Fig. 1. Scheme of hybrid algorithm using GA and neural network

Viewed hybrid neural network genetic algorithm (GA + neural network), in which the radially basic neural network approximator performs the function of the objective function. A distinctive feature of the algorithm is integrated into the GA series of neural network circuit is formed on each iteration of neural network approximation of the objective function, which is used to construct the prediction of optimal solutions using another GA.

The three-stage hybrid algorithm introduced the neural network as part of the learning algorithm of neural network circuit. Different application of the first stage of clustering algorithm with automatic detection of the number of clusters, which allows to

determine the number of hidden neurons and RBNS first approach positions corresponding centers radial basis functions. In the third stage of training error is further reduced by adding new hidden neurons in accordance with the architecture of the cascade correlation of C. Fahlman.

4. Conclusions

The use of this algorithm in the diagnosis turbofan allows:

- Adapt the mathematical model to diagnos object (bypass turbofan engine);
- Effectively solve the problem of optimizing the distribution and flow of information in the face of uncertainty.

We note one joint application GA and neural network - is setting membership functions of fuzzy and neuro-fuzzy systems [5]. Currently, neural networks and genetic algorithms have passed from promising methods for solving problems in the available and widely used methods. The main direction in the development of both new techniques and to solve practical problems related to the search for method research to the time-consuming and increase system performance. One of the approaches discussed in the article - the search parameters of the neural network using the genetic algorithm. Applying this approach to simplify the position with search engineer developer of neural network structure, such as search inputs, the number of layers and neurons in them, the method of training, etc.

These methodological procedures allow a sequence to form a common data set for describing a technical condition engine and a complete set of data for neural network training. Determined the architecture of the hybrid algorithm with neural network and GA.

In the course of studies designed basic technique for the diagnosis of bypass engines with intelligent automated systems.

These methodological foundations provide opportunities for further development of methods and techniques of evaluation of the technical condition of the flow of the turbojet in the parameters of the working process with the depth of diagnosis to a structural assembly with both the split end of the working body, and in the case of mixed streams.

References

[1] Panin V.V., Voznyuk A.P., Popov A.V., Sun Gaoyong (2005) *Influence of gas turbine engine gar-air channel operational factors and damageability on its components*. Proceedings of NAU. №2. P. 49-52.

[2] Kulyk M. (2013) *Method of formulating input parameters of neural network for diagnosing gas-turbine engines* . M. Kulyk, S. Dmutriev, A. Popov, A. Yakushenko. *Aviation – Vilnius: Technika, –* №17(2). P. 52–56.

[3] Korotka, L.I. (2012) *Improving the efficiency of computational methods for modeling the behavior of constructions are the precipitated corrosion*. Dis. of candidate of technical sciences: 01.05.02 . L.I. Korotka. Dnepr, 144 p.

[4] Kuo J.-T., Wang Y.-Y., Lung W.-S. (2006) *A hybrid neural-genetic algorithm for reservoir water quality management*. Water Res.Apr. Vol. 40, no. 7. Pp. 1367-1376.

[5] Saemi M., Ahmadi M., Varjani A. Y. (2007) *Design of neural networks using genetic algorithm for the permeability estimation of the reservoir*. Journal of Petroleum Science and Engineering. 2007. Vol. 59. Pp. 97-105.

[6] Lotfi, E. (2014) *A novel single neuron perceptron with universal approximation and XOR computation properties*. E. Lotfi, M.-R. Akbarzadeh-T. Computational Intelligence and Neuroscience. Vol. 2014. P. 1–6.

[7] Goldberg D.E., Lingle R. (1985) *Alleles, Loci, and the Traveling Salesman Problem,* Proceedings of the First International Conference on Genetic Algorithms and Their Application , pp. 154-159.

[8] Wang L. (2005) *A hybrid genetic algorithm-neural network strategy for simulation optimization.* Applied Mathematics and Computation. Vol. 170. Pp. 1329-1343.

[9] Morimoto T., Ouchi Y., Shimizu M., Baloch M. S.(2007) *Dynamic optimization of watering Satsuma mandarin using neural networks and genetic algorithms*. Water Management. Vol. 93. Pp. 1-10.

[10] Rutkovskaya D. (2006) *Neural networks, genetic algorithms and fuzzy system* per. from Polish. I.D. Rudinsky. D. Rutkovskaya, M. Pilinsky, L. Rutkowski. Hotline Telecom. 452 p.

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В.Е. Потапов

Класифікація нейронних мереж для технічного стану двоконтурного турбореактивного двигуна на основі гібридного алгоритму

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Мета: Представлено метод діагностування технічного стану турбореактивного двоконтурного двигуна з використанням гібридного нейросетевого алгоритму на основі розробленого програмного забезпечення для аналізу даних отриманих в експлуатації. **Методи:** даний метод дозволяє виробляти діагностику двигуна з глибиною розпізнавання до конструктивного вузла при наявності як одиночних пошкоджень конструктивних вузлів проточної частини двигуна, так і багатогранних ушкоджень. **Результати:** представлені результати оптимізації структури нейронної мережі для вирішення завдань оцінки технічного стану проточної частини турбореактивного двоконтурного двигуна, при використанні її спільно з генетичними алгоритмами.

Ключові слова: діагностування; інтелект; проточна частина; турбореактивний двоконтурний двигун.

В.Е. Потапов

Классификация нейронных сетей для технического состояния турбореактивного двухконтурного двигателя на основе гибридного алгоритма

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Цель: Представлен метод диагностирования технического состояния турбореактивного двухконтурного двигателя с использованием гибридного нейросетевого алгоритма на основе разработанного программного обеспечения для анализа данных полученных в эксплуатации. **Методы:** данный метод позволяет производить диагностику двигателя с глубиной распознавания до конструктивного узла при наличии как одиночных повреждений конструктивных узлов проточной части двигателя, так и многогранных повреждений. **Результаты**: представлены результаты оптимизации структуры нейронной сети для решения задач оценки технического состояния проточной части турбореактивного двухконтурного двигателя, при использовании ее совместно с генетическими алгоритмами.

Ключевые слова: диагностирование; интеллект; проточная часть; турбореактивный двухконтурный двигатель.

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